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The effect of shifting between internal and external foci of attention on throwing accuracy

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Abstract

A vast quantity of research has identified the benefits of an external focus on the performance and learning of motor actions. This study aims to isolate the effects that shifting attention between internal and external foci can have on performance. A within subjects design tested the throwing accuracy of 40 undergraduate psychology students in both internal and external focus conditions. Participants threw a tennis ball towards a target with their non-dominant hand over a period of 3 x 2 (counterbalanced) sets of 15 throws. The main effect of focus condition was significant; external focus eliciting higher scores of accuracy. The results are discussed with regards to the Constrained Action Hypothesis in a range of motor activities and performance settings.

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Ethics

Before the data collection phase of the experiment, ethical approval was achieved in accordance with the University of Plymouth's Principles for the Research involving Human Participants. Every participant provided informed consent which was kept confidential (participants were numbered). Participants were able to withdraw their data at any time and given a full debriefing including contact details at the end of the experiment.

Introduction

The way in which we attend to the world is of important psychological interest as people have limited mental resources to process information. Moreover, how we direct our 'focus of attention' can influence our interaction with the environment. For instance, a vast quantity of research has shown that changing the focus of attention during motor activities can have serious implications to the learning and performance of that activity (Wulf, Höß & Prinz, 1998; Wulf McNevin & Shea, 2001; Wulf, 2007). Gabriele Wulf, undoubtedly the principle researcher in this field, offered the example of 'choking' under pressure as a detrimental effect of overly focusing on a motor skill.

Early/pioneering research into attention and motor skill performance was by Baumeister (1984) who used a skill based board game called 'roll up' to test motor control. The game involved moving two metal bars together and apart in order to control the movement of the game ball. This study identified that performance was improved when the participant's attention was focused upon the ball as opposed to their hands.

However, it wasn't until 1998 when Wulf, Höß & Prinz made the first distinction between an internal and an external focus of attention. They suggested that an internal focus of attention is one that is directed towards the performer's own body movements. For instance, during a golf shot, an internal focus would be related to the stance of the performer, how they hold the club, the position of their feet, the movement of their arms and/or the twist of their hips. An external focus of attention is one which is directed to the objects and environment in which the performer is interacting with; the movement effect. To continue with the previous example, an external focus would be towards the motion of the club face, how it swings through the air in a pendulum motion, how it connects with the ball and ultimately, the path of the ball itself.

Wulf, Höß & Prinz (1998) conducted two experiments to test their theory. The first assessed the effect of either an internal or external focus upon how successfully thirty-three novice's learned how to use a ski simulator. Foot movements of experienced skiers on the ski simulator provided the basis for two sets of instructions; one for internal focus and one for external focus. The internal focus instructions were directed towards applying pressure to the outer foot i.e. the foot furthest from the centre of the ski simulator. Conversely, the external focus instructions emphasised the need to apply pressure to the wheels of the moving platform on the ski simulator. Performance on the simulator was determined by the average distance the platform moved on each 90 second trial. There were a total of twenty-two trials, of which five were in the final retention stage of the experiment. Despite the fact the participant's outer foot and wheels of the platform were no more than a few inches apart, the

difference in performance improvement from practice to retention was quite remarkable. After the first trial the performance of all group members was very similar (with average movement of 20cm). During the retention stage however, the external focus condition showed the most improvement with an average of 47cm movement. The internal condition moved on average 31cm whilst the control condition (no performance instructions) moved 41cm.

In their second experiment, an internal and external focus of attention was tested using a stabilometer (device used for testing balance). The internal focus condition instructed participants to concentrate on keeping their feet as horizontal as possible whilst the external condition directed attention towards two horizontal markers on the stabilometer. As is consistent with their first experiment, Wulf, Höß & Prinz (1998) showed that participants in the external condition performed better during the retention test as they could hold their balance with less movement.

These findings stimulated an influx of research into the topic as psychologists explored the limit for attentional effects on motor performance and learning. In terms of basic motor control, directing the focus of attention towards external cues has often had a positive effect on a wide range of arbitrary motor tasks.

Wulf, Tollner & Shea (2007) implemented two such studies. In both, they assessed the balance of participants in either external (focus on rectangles underneath their feet), internal (focus on their feet) or control (told to stand still) conditions. However they were also interested in the link between attentional focus and task difficulty. Both experiments had a 2 x 3 design with participants in external, internal and control conditions being instructed to stand on either a flat surface or a foam surface. The results indicated that despite more postural movement on the foam surface, there was no difference in performance in any of the three conditions. In their second experiment the participants stood on more unstable rubber discs with either one leg or two; designed to be a more challenging motor task than the first experiment. Performance of participants in the external condition was significantly better than those in either the control ($p < .001$) or internal ($p < .05$) conditions. This effect was only present during tasks of increased difficulty. It is important to note however that this was a within-subjects design and each participant took part in the control condition first, the internal condition second and the external condition third. Whilst Wulf *et al* (2007) found that there was a strong order effect; further analysis showed significance only when the order was control-internal-external which maintained their findings. This research shows a limit to attentional focus effects; a certain level of task difficulty is required. Furthermore, the practice effect is something which must be considered in all motor skill repeated measure designs.

Wulf, Dufek, Lozano and Pettigrew (2010) furthered the aforementioned research by focusing on the neuromuscular responses to an internal and external focus of attention. Developing previous research, which found an increased jump height with an external focus (Wulf, Zachry, Granados & Dufek, 2006; Wulf & Dufek, 2009), Wulf *et al* (2010) recorded the electrical activity of five muscle groups necessary for a jump and reach task. They used electromyography (EMG) to record the activity during internal and external condition. Generally, muscle activity was lower in the external condition. As previous research has shown better jump and reach performance in the external condition, Wulf *et al* suggested this type of focus leads

to more efficient and effective muscular movements as well as improved neuromuscular coordination.

If focus instructions can affect motor performance on simple tasks as previously mentioned, then implications may generalize to other activities. In order to increase validity of these assumptions, many psychologists have tested the effect of attentional focus upon sports performance, musical performance and medical treatment.

Lohse, Sherwood & Healy (2010) demonstrated the influence of attention upon dart throwing by assessing both performance and movement quality. Twelve psychology students were assessed on their dart throwing accuracy over three phases of twenty-one throws. The first phase was a control phase whilst the second and third phases were counter-balanced (alternated internal first or external first) between participants. Internal instructions were directed towards the performers arm movements. External instructions however emphasised the need for performers to concentrate on the flight of the dart towards the centre of the target. Overall, the external group threw with less error and thus, their dart throws were closer to the centre of the target on average when compared to the internal focus group. Moreover, EMG activation in the triceps of the external focus participants was lower than in the internal which supports notions of increased movement efficiency.

This finding is reinforced in a more isolated physical test of muscle efficiency by Schucker, Hagemann, Strauss & Volker (2009). Trained runners were instructed to run on a treadmill at a consistent pace for a period of ten minutes per condition. There were two internal conditions in this experiment; one that directed the performer's attention towards their running movement and the other towards their breathing. The latter was also the measure of performance on the treadmill and was recorded with a 'Quark pulmonary gas exchange system' which measured the amount of oxygen inhaled every breath. The external condition directed focus towards the environment and resulted in less oxygen consumption in this repeated measures study. This suggests the efficiency of the working muscles was improved as the same muscle output was present but less oxygen was required.

In an effort to assess the type of external conditions required for optimal performance, Bell & Hardy (2009) tested the effect of two external and an internal focus effect on skilled golfers. Furthermore, they assessed what effect increased anxiety would have on performance in each condition. Thirty three golfers were randomly assigned to one of three conditions and instructed to perform fifty pitch shots over a period of five sets. The three conditions were internal, proximal external and distal external. Bell and Hardy outlined the difference between proximal and distal with regards to external focus. The term proximal refers to the point external, but in close proximity to the source of movement. Conversely, distal refers to the point most external to the source of movement. The distal external condition encourages performers to focus on the 'end-point trajectory'; the performance outcome of the golf shot. Golfers in this condition had greater accuracy of pitch shots whilst the internal condition had the least accuracy. This remained unchanged even during the anxiety condition. These findings further explore the effect of attentional focus and outline a condition for its optimum success. It is important to consider not only the direction of attention, in terms of internal and external focus, but also the

quality of these instructions. It seems the more distal the external cues are from the source of movement, the better the performance.

This was reinforced by Parr & Button (2009) in a 6 week longitudinal study. They investigated the effect of attentional focus on the ability for novices to learn a rowing technique known as 'the catch'. This is the precise moment the blade of the oar enters the water. Participants took part in twenty-four training sessions over a period of six weeks with a qualified rowing coach. Due to the nature of the catch technique, Parr & Button were able to instigate an end-point trajectory in the external condition which is the point most external to the performer; the oar blade. The internal condition focused on the movements of the rower's body. The training sessions were directed, by the coaches, towards either of these conditions throughout the six weeks. The participants were tested seven weeks after the coaching. Participants in the distal external condition showed greater improvements in technique and efficient oar placement when compared to the internal condition. The implications of this study somewhat emphasises the possible applications of attentional focus (focus of attention) towards coaching techniques. It also reinforces the effectiveness of distal external focus instructions with regards to both performance and learning in sports (Bell & Hardy, 2009; Parr & Button, 2009).

A common example of detrimental internal focus is 'choking' under high pressure situations where performers often over think their body movements. Musicians are frequently faced by these situations. Duke, Cash & Allen (2011) demonstrated how external focus and more specifically a distal focus, could improve performance in experienced piano players. Using software specifically designed for the study, Duke *et al* were able to compare accuracy of the musician's performances in an internal (focusing on their fingers) and three external conditions (focusing on the piano keys, piano hammers or the sound produced). The external conditions were of increasing distance from the performer's body movements so that focusing on the piano keys represented the most proximal external condition whilst the sound produced represented the end-point trajectory, respectively. Performance in the external conditions was notably better when compared to the internal. In addition, the more distance in terms of outcome between the musician's movements and their focus cue, the better. For example, those focusing on the sound produced performed better than those focusing on the piano keys. The results not only support the performance effects of external focus in piano playing but also the benefits of a more distal external focus.

The application of focus of attention experiments to medicine can be to either side of treatment; to the medical professionals and to patients with motor deficits. It has been shown how an external focus can have positive effects on performance of motor tasks; which has its implications to surgery and medical treatment. However there is a potentially more pertinent application of an external focus to the medical rehabilitation and coping strategies in patients with motor deficits.

The motor performance of patients with idiopathic Parkinson's disease, a progressive neurological disorder affecting higher level motor neurones, was investigated by Wulf, Landers, Lewthwaite & Tollner (2009). Fourteen patients were told to stand on inflated rubber discs and maintain their balance as best they can. In the internal condition participants were told to focus on their feet whilst those in the

external were told to focus on the rubber disk. In the control condition they were given no focus instructions. The experimenter measured postural sway of participants, which represented their ability to maintain balance. In the external condition, participants showed less postural sway compared to the same participants in both internal and control conditions. The implications extend to coping strategies provided by medical practitioners with a requirement to emphasise goal directed as opposed to movement directed concentration. Wulf *et al* (2009) suggest this could reduce the fall risk in Parkinson's patients.

Testing a less severe motor impairment, Laufer, Rotem-Lehrer, Ronen, Khayutin & Rozenburg (2007) investigated attentional focus effects on forty participants with grade 1 or 2 (measure of severity) sprained ankles. Participants were asked to focus on internal or external cues while attempting to maintain balance on the Biodex Stability System (BSS); an electronic device used to measure anteroposterior (front to back) and mediolateral (side to side) stability. Participants were tested on their ability to maintain balance both before and after a three day training schedule using the BSS. In both conditions an improvement in stability was evident after the training. Greater improvement was observed in the external focus condition suggesting attentional effects have a role to play in the effectiveness of rehabilitation techniques.

The link between an external focus of attention and the likelihood of motor activities producing a desired outcome is clear. There is a vast field of evidence highlighting the importance of external emphasis on motor instructions.

It is important to consider the effect of novice or expert subjects; implications could be to top level sports performers as well as at grass roots level. In many cases, the performance improvements are notable in many skill levels. Wulf & Su (2007) showed that an external focus can lead to better performance of golf shots in both beginner and semi-pro golfers. Gabriele Wulf (2008) later investigated the use of an inflated rubber disk on professional acrobats; who were deemed as experts in balance. Performance in the external condition did not differ from that of the internal which suggests a limit to the effect of focus of attention in high performance sportsman. However this strengthens the relation to novice performers, which takes the research a step closer to understanding the effects of focus of attention.

The obvious difference between novices and experts is the extent to which they have rehearsed and practiced motor actions. With regards to focus of attention, it is fundamental to note the difference in a learning effect and a performance effect. An improvement in learning assess' the difference in pre-test and post-test task performance as a result of an acquisition and retention phases. This is a more or less permanent effect on task performance. The constrained action hypothesis (Wulf, Shea & Park, 2001) suggests that when people focus on the effect of their movement they become more automatic and apply less conscious effort to their muscle movements.

Conversely, performance effects have a more immediate, but temporary effect on motor activity. Understandably there is a growing interest in motor skill learning and focus of attention effects due to the coaching and teaching implications in a vast number of fields. Arguably however, the suggestion that merely directing a

performer's focus of attention towards internal or external cues can have such immediate and often large performance effects is hard to ignore.

Previous studies tend to favour the use of a between subjects design. This allows room for extraneous variables such as capacity of attention, motor co-ordination and skill level. Moreover, the within subjects research available in this field applies only one set of trials per condition (Wulf & Su, 2009) which is limited to the extent a cause and effect relationship can be inferred. Finally, majority of motor tasks used in tests of attention assess relatively common motor activities or sports related tasks. With regards to novices; knowledge of the correct technique is either provided as part of the experiment or available through previous observation.

The extent to which a shift in attentional focus (between internal and external) can influence novices over a period of trials remains unclear. The aim of the current study is to investigate the effect of an internal or external focus of attention upon throwing accuracy. Participants will be asked to throw a ball, with their non-dominant arm, towards a three ringed target in either an internal or external condition. Using a within subjects design and counter-balancing conditions over six short sets of trials, the practice effect should be limited. Also, having six sets of trials will strengthen the reliability of any correlations that may be found. By using this study design and the use of a relatively unfamiliar motor task, extraneous variables should be reduced and performance effects isolated, as far as possible. The present study aims to resolve shortcomings in previous research; reducing individual differences, knowledge of technique and the practice effect. The aim is to promote a raw investigation of the shift in attention upon immediate performance effects in a relatively controlled motor task. The hypothesis states that an external focus of attention will lead to better throwing accuracy.

Method

Participants

Forty (40) male psychology students at the University of Plymouth participated in the experiment as part of their course requirement; 36 right handed and 4 left. The students were rewarded with a point for their participation in the study which contributed to the 22 point requirement of their research methods module. Pre-screen restrictions on the participant point system limited study sign ups to males only in order to increase the homogeneity of the sample. All the students provided informed consent before participating in the experiment.

Materials

The study was held in two of the University of Plymouth's psychology research rooms; 210 and 217, which were of adequate size to cater for the experiment. An information sheet (Appendix A) was supplied to outline the procedure, as well as the consent form (Appendix B) and debrief sheet (Appendix C) as required by ethical guidelines. The internal and external focus description sheets were based upon those in Lohse, Sherwood & Healy's (2010) to ensure similar effects on focus of attention. The internal description focused on the participant's arm movement; *"...visually focus on the target whilst mentally focusing on the movement of your arm. When you're off target think about how you can correct the mistake by changing the motion of your arm. Each time you throw, focus on your arm and think about how*

you are moving. Focus on the motion of your arm while being as accurate as possible..." (Appendix D).

The external focus condition was directed towards the flight of the ball; "...visually focus on the target whilst mentally focusing on the flight of the ball. When you're off target think about how you can correct the mistake by changing the flight of the ball. Each time you throw, focus on the ball and think about how it flies. Focus on the flight of the ball while being as accurate as possible..." (Appendix E).

The same Karakal Pro-ZP tennis ball was used for every participant in all conditions and was thrown towards a target of which the outer ring was 3.30 metres away from the throwing line. Masking tape was used to mark the line that participant's stood behind while throwing and was also used to fix the target to the floor.

The target

There were three sections to the target (see Figure A) – a centre circle, middle ring and outer ring – each of which represented an accuracy score. Three points were awarded for the centre circle, two for the middle ring and one for the outer ring respectively. No points were awarded for a miss. The dimensions of the target are as follows; the centre circle had a diameter of 19.3cm, the middle ring had a diameter of 38.1cm and the outer ring a diameter of 57cm. From the throwing line to the edge of the outer ring was 3.30 metres and thus, the distance to the centre of the target was 3.585 metres.

Design and Procedure

In this 'within subjects design' both independent variables (internal and external focus of attention) were applied to each participant. Before the focus of attention was induced, participants were given an information sheet and consent form which outlined the procedure of the experiment and fulfilled ethical requirements (Appendix A & B). Any questions were answered and a brief verbal explanation of the procedure was also provided. In order to reduce the effect of learning and isolate the dependent variable (throwing accuracy) participants were put through 3 (sets of trials) x 2 (focus condition) sets of 15 throws (6 sets, 3 for each condition). The conditions were counter-balanced between numbered participants; those with odd numbers read the internal description sheet first, whilst those who were evenly numbered read the external description sheet first. Participants were numbered in the order they took part. This meant the effect of learning was standardised as far as possible between conditions. Due to the within subjects design and the study's aim to assess performance effects alone, a control condition was deemed unnecessary.

For each set of throws, the participants read one of the two description sheets depending on the set number and their participation number (odd numbers started with internal and even numbers started with external). The description sheets were based upon a similar descriptive technique as in Lohse, Sherwood & Healy's (2010) study on dart throwing. They were then asked to stand behind a line 3.30 metres away from the nearest edge of the target (3.585 metres from the centre). The target was taped to the floor. Before the throws began, the experimenter verbally reinforced the focus of attention (Appendix F). Participants were instructed to throw a Karakal Pro – ZP tennis ball towards the target so that the first bounce was as close to the centre of the target as possible. Every participant did this with their non-dominant

hand. This was determined as the hand they do not write with. The experimenter asked the participant which was their non-dominant hand and this was recorded. No information regarding technique was provided. The accuracy of each throw was recorded with a score of 3 for the centre, 2 for the middle ring, 1 for the outer ring and 0 for a miss. If the ball clipped the line of a section nearer the centre of the target, then the higher score was awarded (see Figure B). In order to reduce disruption for the participant, the experimenter passed the tennis ball back to the participant after every throw. It is important to note that for every trial in every experiment, the experimenter stayed the same.

When the 6 sets of throws are completed, the participant was given a debrief sheet (Appendix C) which outlined the aims of the study, previous research, the ability to withdraw data and a means of contact with the experimenter. A chance was given to the participants for any further questions and these were answered by the experimenter.

Accuracy recordings were analysed with a within subjects ANOVA (to test the main effect of throwing accuracy of both focus conditions and the interaction that the order condition may have upon this) and a between subjects ANOVA (to test the main effect of throwing accuracy in both order conditions). Finally, T-tests analysed the data sets according to their order condition.

Results

Descriptive Statistics

Participants in the external condition had a higher mean accuracy in both order conditions ($M = 1.14$, $SD = .31$) when compared to the internal ($M = 1.01$, $SD = .31$). Those who took part in the internal condition first had a higher mean accuracy during their external focus throws ($M = 1.16$, $SD = .32$) than when they were in the internal ($M = 1.03$, $SD = .31$). Similarly, participants who were put through the external condition first still performed better in the external ($M = .99$, $SD = .31$) than in the internal ($M = 1.12$, $SD = .31$). See Figure 1.

<i>Descriptive Statistics</i>			
	Order	Mean	Std. Deviation
Internal	1.00	1.0342	.30833
	2.00	.9933	.30970
	Total	1.0137	.30573
External	1.00	1.1592	.32388
	2.00	1.1214	.30596
	Total	1.1403	.31157

Figure 1: A table to show the means and standard deviation in both order and focus condition (1.00 = Internal first, 2.00 = External first).

Mean Throwing Accuracy

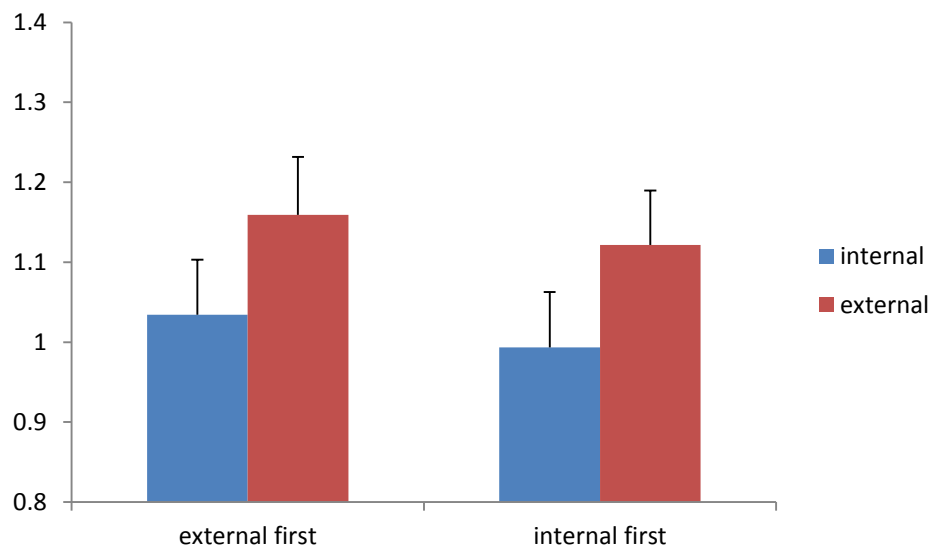


Figure 2: The graph shows mean accuracy of throws with respect to order and focus conditions

Figure 2 highlights the difference between focus conditions; in the external conditions participants threw more accurately on average than in the internal condition. There is a slight difference in the order and throwing accuracy; when internal focus was implemented first, both internal and external conditions exhibited greater mean accuracy.

Tests of within subjects effects

The average score of accuracy in both internal and external conditions for each participant were entered into a One Way Repeated Measures ANOVA. The results of which were significant at the 1% level, $F = (1, 38) = 8.05$; $p = .007$, $MSE = .320$ (Figure 3).

Tests of Within-Subjects Effect: main effect of focus condition upon throwing accuracy

Measure: Accuracy

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Focus	Sphericity	.320	1	.320	8.045	.007	.175
	Assumed						
	Greenhouse-Geisser	.320	1.000	.320	8.045	.007	.175
	Huynh-Feldt	.320	1.000	.320	8.045	.007	.175
	Lower-bound	.320	1.000	.320	8.045	.007	.175

Figure 3. A table to show the tests of within subjects effects in the one way repeated measures ANOVA.

There is a main effect of focus as the F value (8.05) is significant at $p < 0.1$. From the descriptive statistics previously mentioned (*Figures 1 and 2*) it is clear the significant main effect is in favour of the external condition.

The interaction of order upon the within subjects focus differences observed above was also analysed. Whether participants were in the internal first or external first had no significant interaction upon the differences observed in between focus conditions, $F(1, 38) = .001$, $p = .973$, $MSE=4.67$ (*Figure 4*).

Tests of Within-Subjects Effects: the interaction of order upon accuracy in focus conditions

Measure: Accuracy

Source		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Focus Order	* Sphericity Assumed	4.668E-5	1	4.668E-5	.001	.973	.000
	Greenhouse-Geisser	4.668E-5	1.000	4.668E-5	.001	.973	.000
	Huynh-Feldt	4.668E-5	1.000	4.668E-5	.001	.973	.000
	Lower-bound	4.668E-5	1.000	4.668E-5	.001	.973	.000

Figure 4. A table to show the interaction of order and focus on accuracy.

Tests of between subjects effects

In the same test a between subjects factor was entered to assess the main effect of order. The results were not significant, $F(1, 38) = .199$; $p = .658$, $MSE=.031$. Whether the participants were in the internal or external condition first had no significant effect upon throwing accuracy (*Figure 5*).

Tests of Between-Subjects Effects

Measure: Accuracy

Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	92.797	1	92.797	598.896	.000	.940
Order	.031	1	.031	.199	.658	.005
Error	5.888	38	.155			

Figure 5. A table to show the tests of between subjects effects as a result of the ANOVA.

Paired samples T-tests

Within the internal first order condition, a comparison of the means between internal ($M= 1.10$, $SD= .07$) and external focus ($M= 1.16$, $SD= .07$) was significant at the 5% level, $t(19) = -2.28$, $p = .03$. The 95% confidence interval of difference was $-.24$ for the lower bound and $-.01$ for the upper bound.

During the external first order condition, the internal focus mean was .993 (SD= .31) and the external focus was 1.12 (SD= .31). This difference was also significant $t(19) = -1.82$, $p = .09$. The 95% confidence interval of difference was -.28 for the lower bound and -.02 for the upper bound.

Dominant throwing participants

Notably, the data set had some inconsistencies regarding the participant's throwing arm. In order to standardise the procedure, the experimenter instructed participants to throw with the hand they don't write with. In three cases (participants 18, 29 and 38) the hand which was classed as the participant's non-dominant hand was also the hand they most prefer throwing with. When these participants were taken out of the data set, the average accuracy in the external focus condition ($M = 1.12$, $SD = .31$) was still higher than in the internal ($M = 1.02$, $SD = .31$). This difference was significant ($F = (1, 35) = 5.71$; $p < .05$). Moreover, there was still no significant interaction between order and the main effect of focus ($F = (1, 35) = .784$; $p = .38$).

Qualitative Data

Whilst this was designed to be a quantitative study, it was recorded when participants made comments regarding their preference for focus conditions. Additionally, it was noted when participants had dramatic changes in technique between focus condition.

Participant 29 threw the tennis ball faster and more directly in the internal condition compared to the external condition. Conversely his throws in the external condition were slow and loopy.

Participant 32 mentioned on several occasions 'how much easier' he found the external condition compared to the internal.

Participant 39 also stated a preference for the external condition.

Discussion

The present study demonstrated that an external focus of attention leads to greater scores of throwing accuracy in novices. This main effect of focus was statistically significant which rejects the null hypothesis and supports previous findings of attention on immediate motor task performance.

Due to the nature of the repeated measures design, it would be natural to assume that the order of focus condition may affect task performance through practice and acquisition. This was not the case in this study, as any interaction of the order conditions on internal and external focus performance differences, was not significant. Furthermore, there was no main effect of order condition upon throwing accuracy, suggesting the practice effect had little impact on throwing performance. This was supported by two t-tests which showed a significant difference in mean accuracy of focus within each order condition. This demonstrates that even by separating the two order conditions (20 participants each), performance benefits of the external focus are still present. The statistical analysis infers little effect of order condition upon the main effect of focus instructions which strengthens the suggestion of a cause and effect relationship between focus and throwing accuracy.

When the 3 participants who threw with their dominant arm were excluded from the data set, the relationship between an external focus and greater throwing accuracy remained significant (compared to the internal focus). Notably however, the main effect of focus was at a lower level of significance (5% as opposed to 1%) which may be as a result of a higher level of expertise; well rehearsed motor tasks tend to instil a preference for external focus (White, Reber & Owen, 2008). In addition, simply removing participants from a data set is likely to affect significance levels. The order of the internal and external conditions had no bearing on the differences in accuracy between them.

Previous research has shown that external focus of attention can increase motor control (balance & precision), muscle power output (jump and reach) and muscle efficiency (EMG activation & oxygen intake) in a wide range of applications (basic motor, sports, medicine & music). The present research supports these findings with an emphasis on immediate performance effects in novices. As there were six trials (three for each condition), the results strengthen suggestions of a cause and effect relationship between external focus and throwing accuracy. Implications of which extend to immediate improvements for novices in sports, music, medical rehabilitation and any other motor tasks where success is dependent upon a movement outcome. Indeed, during such motor tasks there must be an opportunity for instructions to direct the attention of the performer. Coaches and teachers must consider the direction of focus whilst instructing novices on performance. Often sports development revolves around improving technique which encourages performers to focus internally. Research into attentional focus, including the current experiment, suggests this may not be the optimal focus for success in sports related motor activities. Instead, it seems coaching instructions should be directed towards external cues. Wulf, McNevin, Fuchs, Ritter & Toole (2000) examine focus during golf shots and show that technique related instructions outperform focusing on the ball trajectory. Whilst both of these conditions are external, the findings aren't consistent with that of distal focus research; it seems technique should not be ignored but instead, directed towards external goals.

Temporary performance effects have a role to play during high anxiety conditions. Flegal & Anderson (2008) tested beginner and intermediate skill golfers on putting tasks. After a series of practice trials, participants were told to either describe their experience of putting in detail or took part in a verbal control task. The results found that when intermediate golfers described the putting task, their performance decreased. This was not the case for the intermediate golfers in the verbal control task. The verbal exercise had no effect on beginners. This was explained by higher skilled golfers 'over thinking' their movements. In the current research, detrimental effects of an internal focus could be similarly explained. It has been put forward that anxiety may also lead to over thinking (Wulf, 2007) which infers application to high pressure situations.

The current experiment is one of the few repeated measures designs testing focus of attention in novices. It is also one of the few not to include a control condition. The main reason for this is that a control would increase the likelihood of practice effects confounding the data. Participants would have undergone forty-five extra throws and this would most likely have encouraged learning through practice; confounding the experimental focus conditions. Indeed, the drawback here is that results cannot be

compared to a baseline throwing accuracy for each participant. It is hard therefore to identify if the effects of external focus instructions can improve accuracy compared to no attentional instruction. However, in a control condition, experimenters may only speculate to the focus of attention elicited for each trial by the participant. So whilst experimental conditions attempt to investigate specific foci, control conditions could be testing a variety of different forms of attention. In addition, it is important to note, that the current experiment is investigating the effects of an internal versus external focus of attention which has its implications to activities relying on attentional instruction.

The main drawback of the experimental design was the interpretation of where the tennis ball landed on the target. As aforementioned, when the ball clipped the line separating the rings of the target, the score was taken of the more central ring. This was standardised as far as possible for each trial in each condition as the same experimenter was used throughout. However, in order to reduce the likelihood of human error and increase reliability, it would be beneficial for future research to video each trial. Alternatively, two experimenters could record separate accuracy ratings and make comparisons between the two interpretations. This would promote more accurate and reliable records of throwing performance.

Undoubtedly the most comprehensive theory of attention and motor action is the Constrained Action Hypothesis (CAH) (Wulf, McNevin & Shea, 2001). The theory makes a clear distinction between an internal and external focus of attention. During the internal focus performers are said to consciously, but unintentionally, interfere with the automatic control processes required for effective motor coordination. Doing so, they disrupt the smooth, fluid, accurate and consistent movement which results from automatic processes. Conversely, when attention is directed away from body movements and towards the outcome, motor control becomes automatic; with little conscious interference. The external condition encourages unconscious and reflexive control of motor action.

It is important to note that whilst the theory, and indeed the majority of research, suggests focus should be directed away from internal cues, it is only when focusing on the desired outcome that improvements in external focus performance are seen. Wulf, McNevin, Fuchs, Ritter & Toole (2000) applied two focus conditions to tennis players; antecedent (focus on the incoming ball) and effect (focus on the ball leaving the racket). The effect group outperformed the antecedent group in terms of learning. The role of the external condition is not entirely on drawing attention away from consciously interfering motor processes, but also to focus on the outcome.

The CAH proposes that beginners tend to focus their attention to internal factors whilst learning or performing unfamiliar motor tasks. Wulf (2007) suggests performers overly attend towards new movement patterns or are provided instructions of technique during the initial stages of learning. It is natural for beginners to experience anxiety during new motor tasks as they have little experience and don't want to fail. It is for this reason that in vast amounts of previous research, the performance effects of novices in both internal and control conditions have been similar.

The findings from the present research can be explained by the CAH. During the internal condition, participants were directed to focusing on the movement of their arm. Conscious control disrupted the automatic processes leading to inconsistent and lower scores of accuracy (compared to the external). During the external condition, automatic processes took over motor control leading to consistent and accurate throwing performance.

It is important to note that the relevance of automatic processes plays a part in their application to motor tasks in external focus conditions. The CAH theorises that automatic processes of well rehearsed tasks may be applied to the unfamiliar or less practiced task at hand. For example, in the current experiment, it may be suggested that during the external condition participants throwing with their non-dominant hand drew from automatic processes learnt whilst throwing with their dominant hand.

Evidence for the CAH, and its assumptions of automaticity in external focus conditions, comes in three forms according to Wulf (2007); frequency of movement adjustments, differences in attentional demands and recordings of muscular activity. The former stems from attention research involving balance tasks and draws from the assumption that good balance is a product of high frequency and reflexive movements. Using a Fast Fourier Transform movement analyses technique, McNevin Shea and Wulf (2003) were able to test the mean power frequency of performers on a stabilometer. Participants were placed in one of four conditions; two distal external (focus on markers at either end of the platform), one proximal external (focus on markers near feet) and one internal (focus directed towards feet). Mean power frequency was lower in the internal than the any of the external conditions, and thus their balance was less effective. Furthermore, the two distal conditions led to the highest mean power frequency which further distinguishes the effects of external attention on frequency of movement and provides support for the CAH.

The amount of attentional demands on a performer can change as a result of expertise. For example, Leavitt (1979) demonstrated that expert ice hockey players were able to maintain speed of skating and accuracy of stick handling whilst having to respond to a secondary task; naming geometrical shapes. The skating speed of novices was slower whilst they had to perform the same secondary task. The findings suggest performers with higher skill levels perform motor tasks with less conscious effort allowing attentional demands to be met elsewhere. The CAH proposes this is as a result of increased automaticity in performers who externally focus. Wulf, McNevin & Shea (2001) applied a dual task procedure in an effort to test capacity of attention in different focus conditions. A stabilometer was used to test balance whilst a secondary task instructed performers to respond to a series of high pitch or low pitch tones. The response times were shorter in the external condition compared to the internal. This was explained by an increased availability of attention towards the secondary task as a direct result of balance automaticity.

Muscular activity, as previously mentioned, tends to be higher in the internal condition compared to the external (Lohse, Sherwood & Healy, 2010). This is explained through heightened muscle efficiency when focusing on the movement effect. The CAH postulates conscious control of the muscles (internal) leading to activation of muscle groups which aren't required (Zachry, Wulf, Mercer Bezodis,

2005) thereby wasting energy. In turn this explains the less reliable movements which seem typical of internal focus.

On average the data showed greater accuracy during external conditions and less accuracy during internal conditions, even though conditions were alternated; this highlights the presence of temporary performance effects. Throughout the article, a distinction has been made between the performance effect and the learning effect in attentional focus investigations. It seems however the only difference between the two is whether the quantity of trials sufficient for learning is met during a single focus condition. If the quantity of trials is not met, performance improvements will only be temporary. Assuming this, motor task benefits will be present during periods of external focus whether the aim is to induce either temporary or long-term effects. Therefore, it is possible to apply Fitts & Posner's (1967) three stages of learning to even temporary performance. The three stages occur in order during learning. The first stage, Cognitive, is categorised by forming a mental image of the motor skill. As interpreted by Wulf (2007), learners in this stage are under high cognitive demand and it is suggested that movements are controlled consciously. In the Associative stage, learners become more competent at the motor skill, with increased reliability and fluidity of movements. There is said to be less conscious control as some of the motor control becomes automatic. The final stage, Autonomous, is acquired after vast amounts of practice and effortlessly consistent skill performance is typical. In the final stage, little or no attentional demands are present as movement is said to become automatic. (Wulf, 2007)

The CAH has suggested that an external focus of attention leads to more automatic and less conscious control of movement; even in novices (Wulf, McNevin & Shea, 2001). Perhaps then, directing attention towards movement effects as opposed to the movement itself allows performers to optimise learning by shortening or even skipping Fitts and Posner's first phase of learning. Zentgraf & Munzert (2009) demonstrated through the use of biomechanical analyses that attention can impact the nature of body movements during juggling. Through this, they found that internal focus participants were subject to a conflict between focusing on the movement and the outcome (movement effect) of juggling. Zentgraf & Munzert suggest that when novices focus internally they are required to process more information about the task (body movements and outcome effects) as opposed to external (outcome effect). This can be applied as an explanation for increased accuracy in the present study. If performers attend less towards their movements (as in the external condition) they have the capacity to focus on where the ball lands on the target; the outcome/movement effect.

Wulf & Su (2007) conducted two experiments testing the accuracy of golf shots in both novices (undergraduates) and high level performers (average handicap 1.3). Over a series of 70 pitch shots (60 practice, 10 retention), novices displayed no significant difference in learning between the three focus conditions (internal (I), external (E) and control (C)). In their second experiment, high level performers were put through all three focus conditions in a counterbalanced design (CIE, ECI, IEC). The expert golfers had greater accuracy of pitch shots whilst focusing externally compared to either internal or control conditions.

The findings lead Wulf & Su (2007) to discuss focus of attention in performers of different skill levels and with regards to an optimal focus. As aforementioned, attentional demands tend to be higher during early stages of skill learning and lower as performers become experts. Thus, experts tend to have the ability to focus on higher level factors during motor actions. Wulf & Su suggest a hierarchy of focus which is dependent upon skill level; higher level external foci are attended to in expert performers. This is primarily due to 'automatization' (movements become automatic) of lower level foci. For example, high level focus would be towards the backspin elicited on a golf ball during a pitch shot. For novices however, they would tend to focus on lower level cues such as trying to hit the ball cleanly or even directed towards internal cues such as the movement of their body. High level goals are often a result of several low level processes. This 'hierarchy of attention' stimulates the pursuit of optimal focus as is determined by skill level.

The CAH promotes the theory, with three key areas of evidence, for automatic processes taking control during external focus conditions. However, recent criticisms by Peh, Chow & Davids (2011) towards the CAH have been outlined. They consider that the majority of research is directed towards the movement effects that an external focus seems to elicit as opposed to 'movement dynamics' (coordination). Whilst muscular efficiency has been shown to improve after external focus instructions (Schucker, Hagemann, Strauss & Volker, 2009) little research solely examines movement dynamics. With the emphasis being on the outcome of motor actions in the majority of research, the effect of an external focus is understandable (as performers are focusing directly on the outcome). Peh *et al* (2011) highlight the need to focus on movement coordination in tasks of attention. For example, motor tasks such as dancing, where performance is directly dependent on body movements, may be performed optimally with an internal focus. This raises the question how performance is defined and measured during research into attention.

Also unclear, is the extent to which tests of attention assess 'beginners'. Drawing from the CAH model, beginners and novices are able to apply automatic processes learnt in other motor tasks to the one they have had no previous experience with. If this is the case, some participants in attentional research may be able to apply more automaticity to unique tasks than others, and thus be further along Fitt's stages of learning. An interesting approach would be to assess the focus direction of babies and toddlers during motor actions (such as crawl or walk). This would ensure fewer automatic processes are available. If an internal focus of attention proves more effective in performance and learning, then this would support the CAH whilst emphasising the effect of previous experience on motor learning. The challenge though, is successfully directing focus at such a young age.

Another direction for future research is to examine brain activity during periods of internal, external and no focus instruction. The implications of which could provide an insight into validity of instructional techniques on attention, monitor the focus during control conditions and importantly, provide further understanding of automaticity.

Previous accounts of attentional research demonstrate the performance benefits of focusing on the movement outcome during motor tasks. The result of this experiment strengthens the link between focus of attention and immediate task performance.

Additionally, these findings can be explained by the CAH model in terms of the inhibition and automaticity of motor processes during internal and external foci.

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References

- Baumeister, R. F. (1984). Choking under pressure: self-consciousness and paradoxical effects of incentives on skillful performance. *J. Pers. Soc. Psychol.* 46, 610–620.
- Bell, J., Hardy, J. (2009). Effects of Attention Focus on Skilled Performance in Golf. *Journal of Applied Sport Psychology* 21, 163-177.
- Duke, R.A., Cash, C.D., Allen, S.E. (2011). Focus of Attention Affects Performance of Motor Skills in Music. *Journal of Research in Music Education. Article in Press.*
- Fitts, P.M., & Posner, M.I. (1967). *Human Performance*. Belmont, CA: Brooks/ Cole.
- Flegal, K.E., Anderson, M.C. (2008). Overthinking Skilled Motor Performance: Or why those who teach can't do. *Psychonomic Bulletin & Review* 15, 927-932.
- Freedman, S.E., Maas, E., Caligiuri, M.P., Wulf, G., Robin, D.A. (2007). Internal Versus External: Oral-Motor Performance as a Function of Attentional Focus. *Journal of Speech, Language, and Hearing Research* 50, 131-136.
- Laufer, Y., Rotem-Lehrer, M., Ronen, Z., Khayutin, G., & Rozenberg, I. (2007). Effect of Attention Focus on Acquisition and Retention of Postural Control Following Ankle Sprain. *American Congress of Rehabilitation Medicine and the American Academy*, 88, 105-108.
- Leavitt, J.L. (1979). Cognitive Demands of Skating and Stick Handling in Ice Hockey. *Canadian Journal of Applied Sports Science*, 4, 46-55.
- Lohse, K. L., Sherwood, D. E., and Healy, A. F. (2010). How changing the focus of attention affects performance, kinematics, and electromyography in dart throwing. *Hum. Mov. Sci.* doi: 10.1016/j.humov.2010.05.001.
- Maas, E. (2010). Conditions of Practice and Feedback in Treatment for Apraxia of Speech. *Perspectives on Neurophysiology and Neurogenic Speech and Language Disorders*, 20, 80-86.
- McNevin, N. H., Shea, C. H., & Wulf, G. (2003). Increasing the distance of an external focus of attention enhances learning. *Psychol. Res.* 67, 22–29.
- Parr, R., & Button, C. (2009). End-point focus of attention: learning the 'catch' in rowing. *International Journal of Sport Psychology*, 4, 616-635.

Peh, S., Chow, J., & Davids, K. (2011). focus of attention and its impact on movement behaviour. *Journal of Science and Medicine in Sport*, 14, 70-78.

Schücker, L., Hageman, N., Strauss, B., and Völker, K. (2009). The effect of attentional focus on running economy. *J. Sports Sci.* 12, 1242–1248.

Vance, J., Wulf, G., Tollner, T., McNevin, N., and Mercer, J. (2004). EMG activity as a function of the performer's focus of attention. *Journal of Motor Behavior*. 36(4): 450-459.

Weiss, S. M., Reber, A. S., & Owen, D. R. (2008). The locus of focus: the effect of switching from a preferred to a non-preferred focus of attention. *Journal of Sports Sciences*, 26, 1049-1057.

Wulf, G. (2007). Attentional Focus and Motor Learning: A Review of 10 Years of Research. *E-Journal Bewegung und Training*, 1, 4-14.

Wulf, G. (2007). Attention and motor skill learning. Champaign, IL: Human Kinetics.

Wulf, G. (2008). Attentional Focus Effects in Balance Acrobats . *Research Quarterly for Exercise and Sport*, 79, 319-325.

Wulf, G., and Dufek, J.S. (2009). Increased jump height with an external focus due to enhanced lower extremity joint kinetics. *Journal of Motor behavior*. 41(5): 401-409.

Wulf, G., Dufek, J. S., Lozano, L., and Pettigrew, C. (2010). Increased jump height and reduced EMG activity with an external focus of attention. *Hum. Mov. Sci.* 49, 440–448.

Wulf, G., Höß, M., & Prinz, W. (1998). Instructions for motor learning: Differential effects of internal verses external focus of attention. *Journal of motor behaviour*, 30, 169-179.

Wulf, G., Landers, M., Lewthwaite, R., & Töllner, T. (2008). External Focus Instructions Reduce Postural A. Svedberg and H.C. Larson, 2002. Effect of Instability in Individuals With Parkinson Disease. *Journal of American Physical Therapy Association*, 91(3), 162-168.

Wulf, G., McNevin, N. H., and Shea, C. H. (2001). The automaticity of complex motor skill learning as a function of attentional focus. *Q. J. Exp. Psychol.* 54A, 1143–1154

Wulf, G., McNevin, N. H., Fuchs, T., Ritter, F., & Toole, T. (2000). Attentional focus in complex motor skill learning. *Research Quarterly for Exercise and Sport*, 71, 229-239.

Wulf, G., Shea, C. H., and Park, J.-H. (2001). Attention in motor learning: preferences for and advantages of an external focus. *Res. Q. Exerc. Sport* 72, 335–344.

Wulf, G., & Su, J. (2007). An External Focus of Attention Enhances Golf Shot Accuracy in Beginners and Experts. *Research Quarterly for Exercise and Sport*, 78, 384-389.

Wulf, G., Töllner, T., Shea, C.H. (2007). Attentional Focus Effects as a Function of Task Difficulty. *Research Quarterly for Exercise and Sport* 78, 257-264.

Wulf, G., Zachry, T., Granados, C., Dufek, J.S., (2006). Increases in jump-and-reach height through an external focus of attention. *International journal of sports science and coaching*, 2, 275-284.

Zachry, T., Wulf, G., Mercer, J., and Bezodis, N. (2005). Increased movement accuracy and reduced EMG activity as the result of adopting an external focus of attention. *Brain Res. Bull.* 67, 304–309.

Zentgraf, K., & Munzert, J. (2009). Motor Imagery and its Implications for Understanding the Motor System. *Progress in Brain Research* 174, 219-229.

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